InSight

JPL

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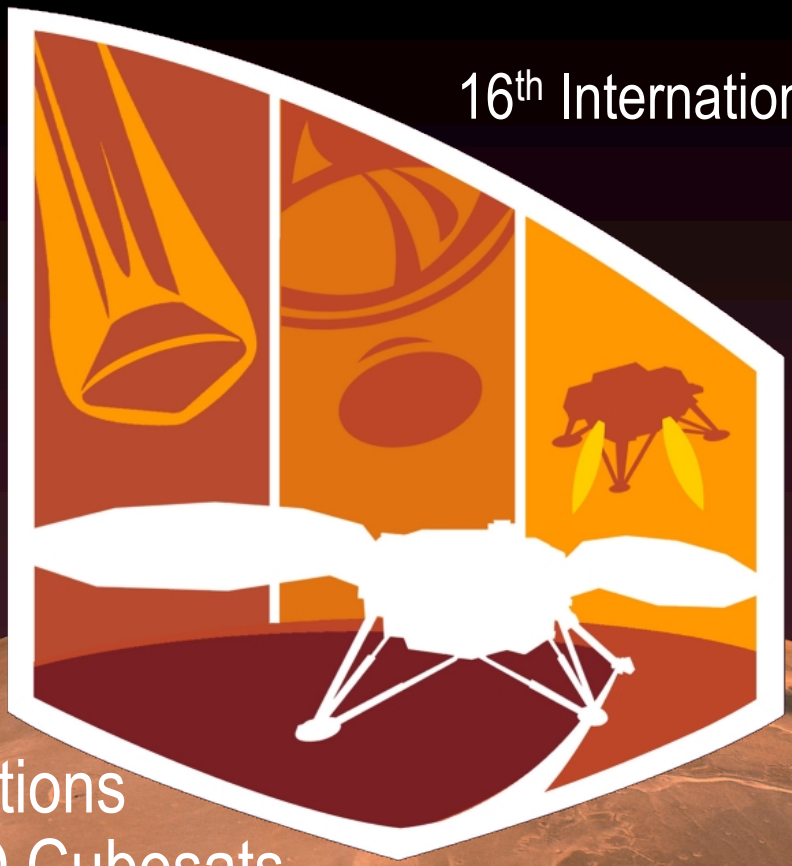
InSight

16th International Planetary Probe Workshop



EDL Communications Featuring MarCO Cubesats

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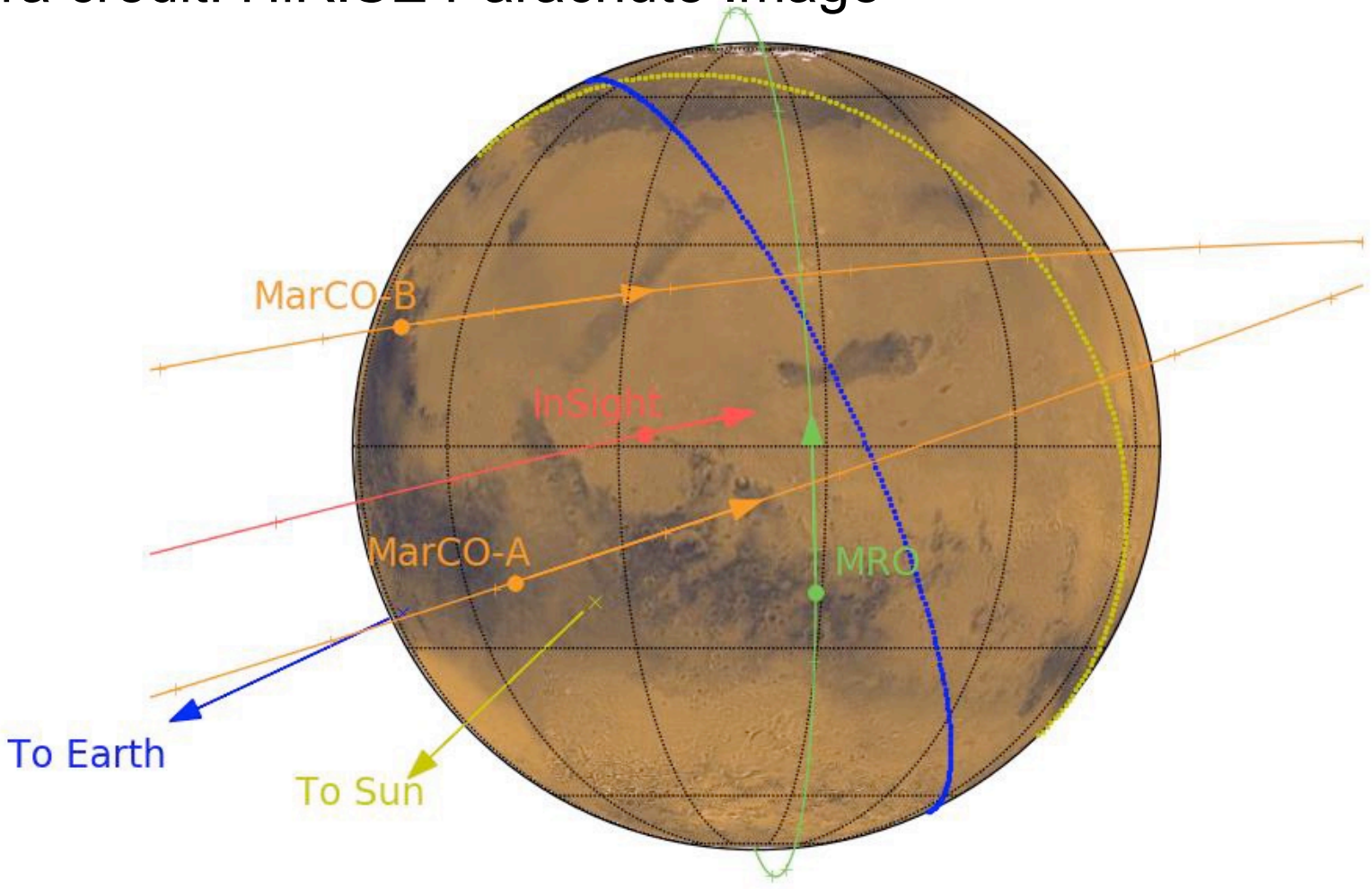
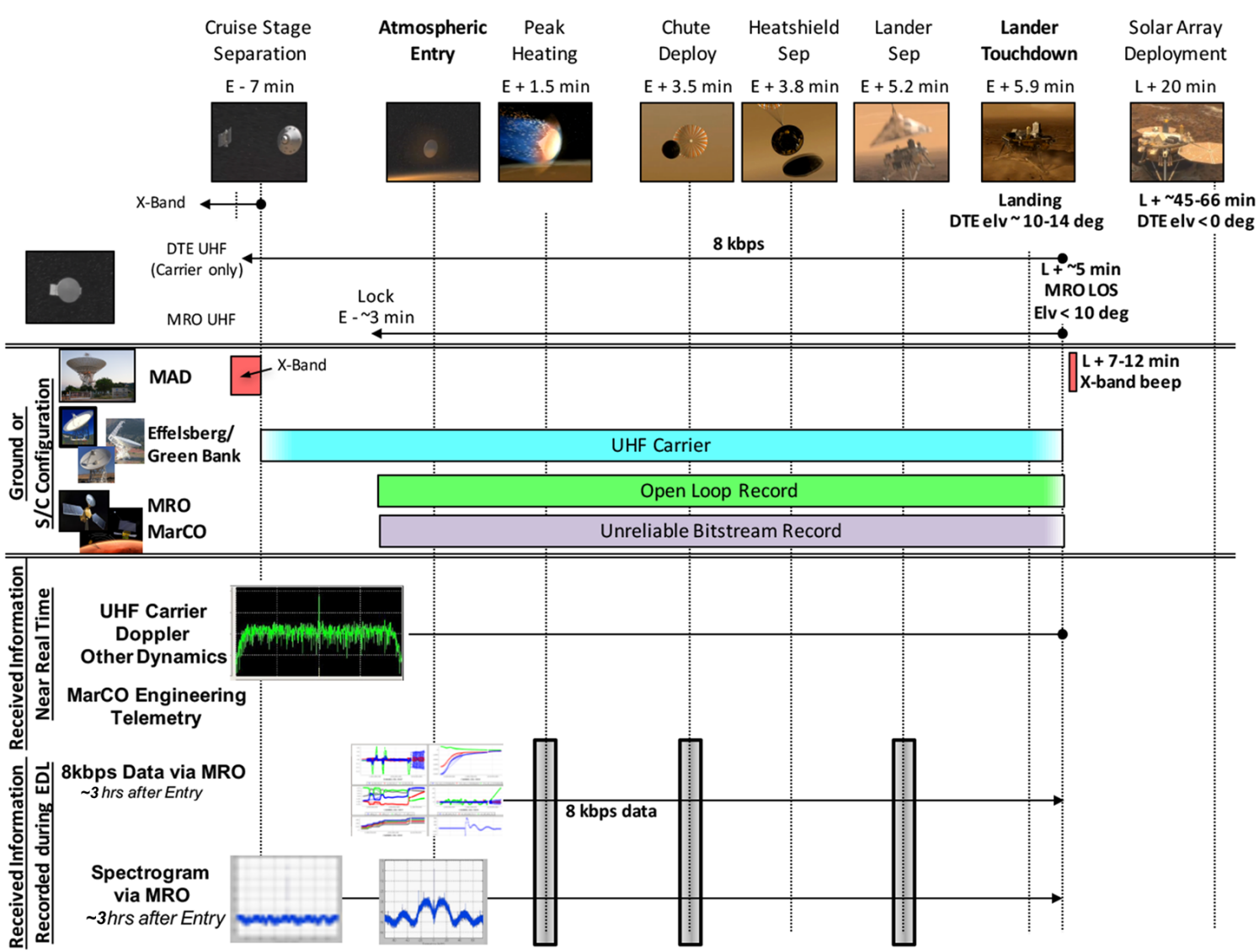
July 9th, 2019

EDL Comm Objectives and Assets

- Capture EDL telemetry for real-time display and
- Post-failure analysis if necessary
- Extra credit: HiRISE Parachute Image

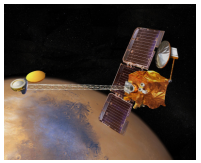


EDL Comm Assets and Timeline



Odyssey Pass

L + 4 hours



Solar Array Deploy Confirmation

EDL Monte Carlo Analysis – Pre-EDL

- Performed by NASA Langley Center
- Leveraged EDL Monte Carlo runs for atmosphere & entry variations
- Added MRO, MarCO & Earth trajectories, models of InSight transmit and asset receive antennas & signal thresholds
- Used Monte Carlo runs to evaluate MRO & MarCO trajectories
- Also used to select times & rates for HiRISE parachute image
- Predicted signal levels were consistent with reconstruction
  - Unexplained MRO signal drop-off

EDL Comm Monte Carlo Scorecard - MRO

Event	Units	1%	Above threshold
Link at Entry-340s	dBm	-142.6	-15.0
Link at Entry-Interface	dBm	-122.9	4.7
Link at Chute Deploy	dBm	-123.2	4.4
Link at Lander Separation	dBm	-117.2	10.4
Link at Touchdown +1min	dBm	-102.3	25.3
Link at Touchdown +5min	dBm	-114.8	12.8
Time at First Line of Sight (99%)	s	238.2	361.8
Min Elevation at TD to TD + 1 m	deg	13.5	3.5
Min Elevation at TD to TD + 5 m	deg	5.1	-4.9
50% Altitude of HiRise before LS	m	6433.6	
50% Altitude of HiRise after LS, bef TD	m		
% of cases seen by HiRise bef LS	%	69.8	
% of cases seen after LS, before TD	%	0.0	
Total % of cases seen	%	69.8	

Event	Units	1%	Above threshold
Link at Entry-340s	dBm	-142.6	-15.0
Link at Entry-Interface	dBm	-122.9	4.7
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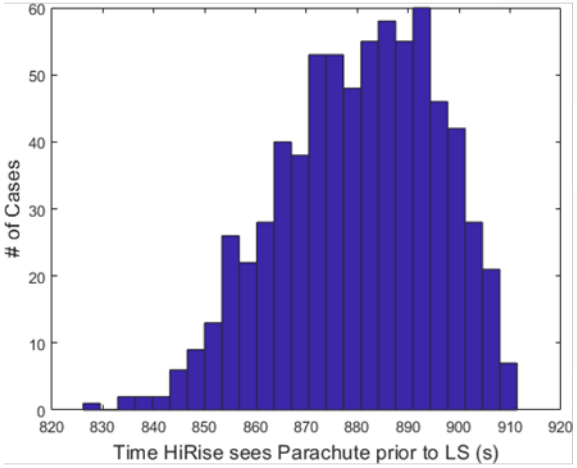
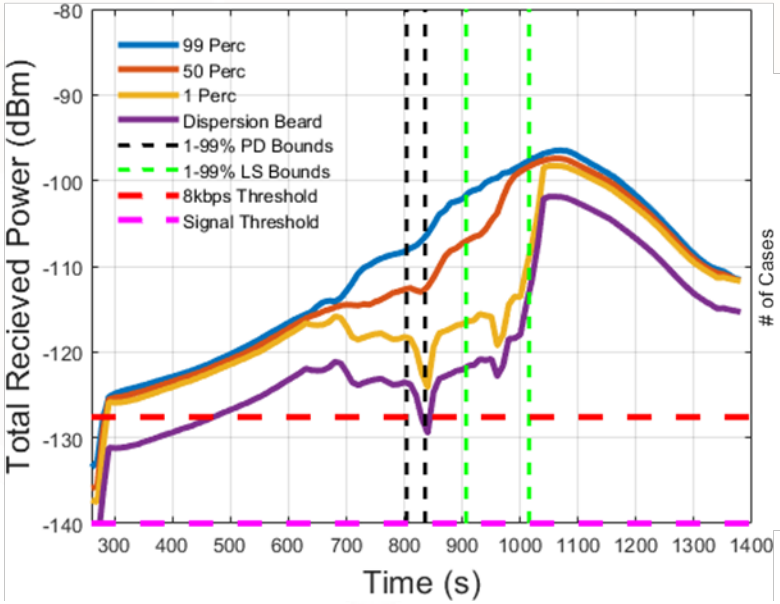
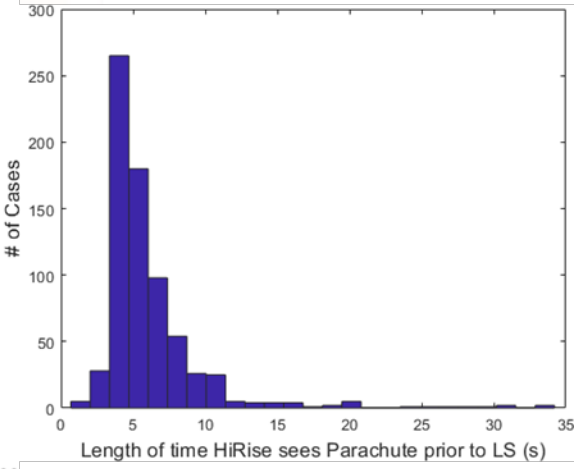
50% Altitude of HiRise before LS	m	6433.6	
50% Altitude of HiRise after LS, bef TD	m		
% of cases seen by HiRise bef LS	%	79.4	
% of cases seen after LS, before TD	%	0.0	
Total % of cases seen	%	79.4	

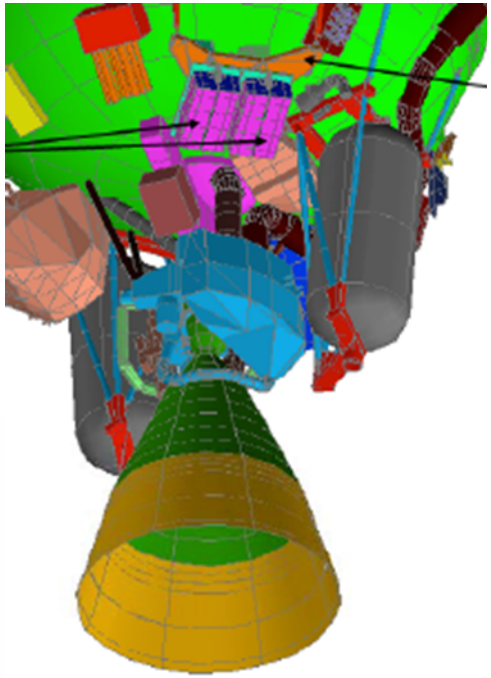


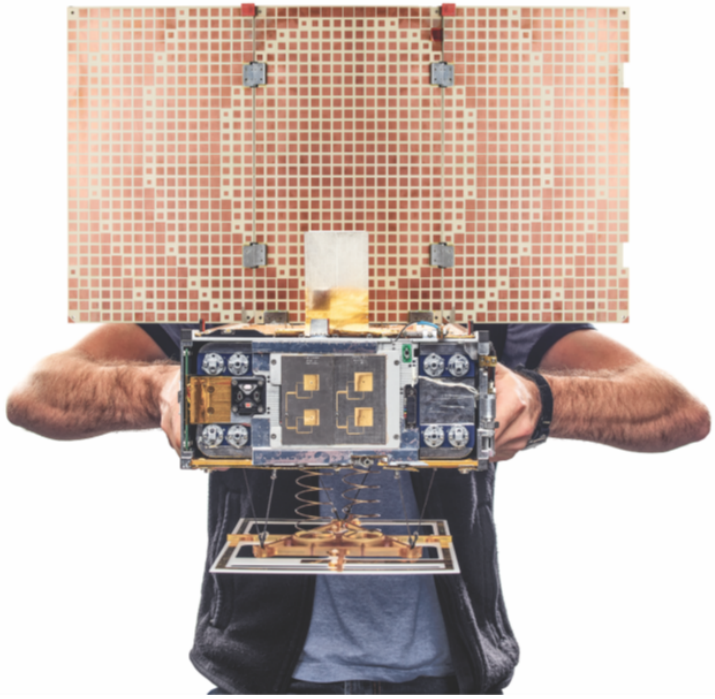




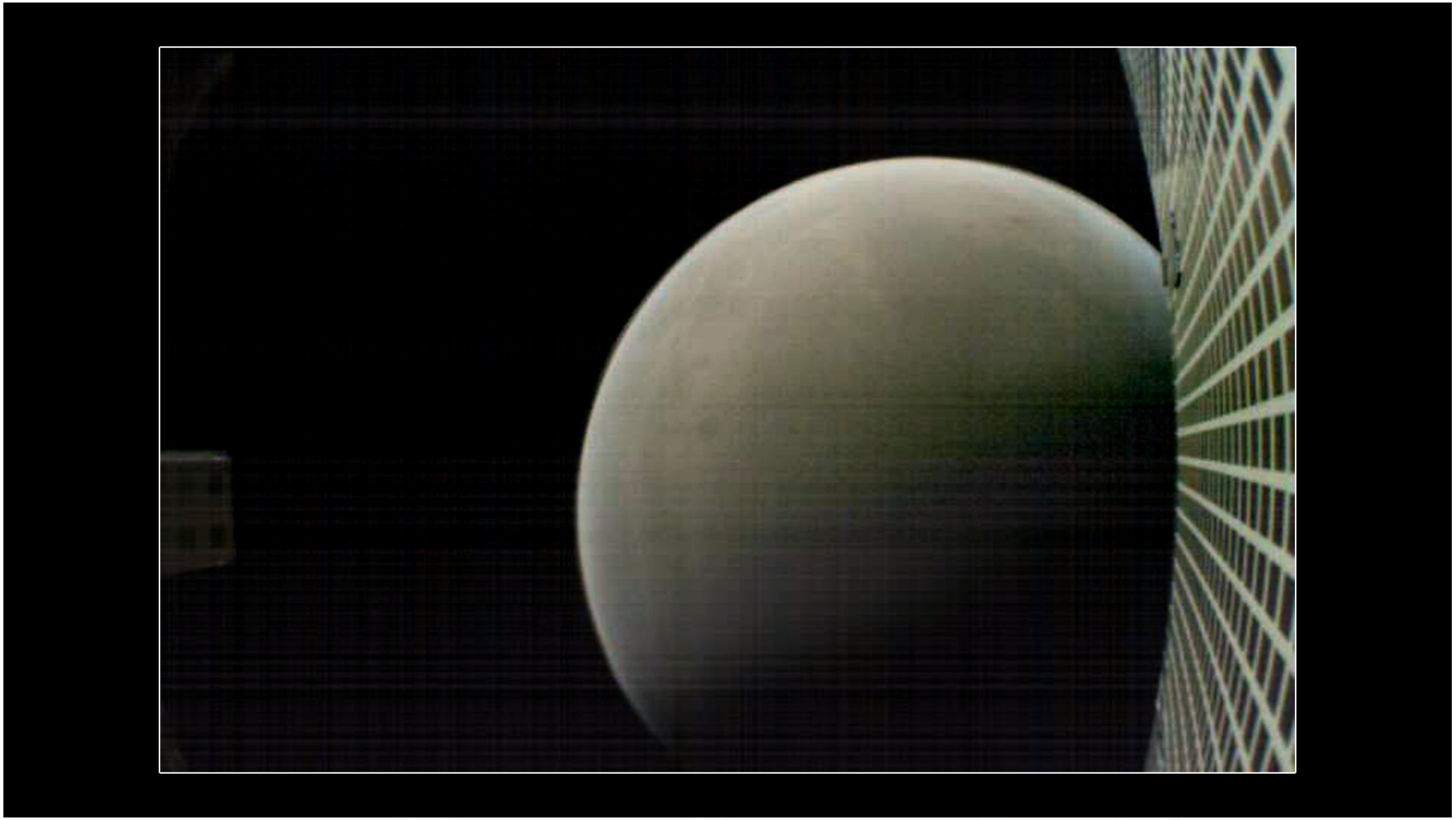
MarCO Cubesats

- First Cubesats beyond lunar orbit
- Launched on InSight launch vehicle; flew formation with InSight to Mars
- Successful real-time data from UHF turn-on through 1st ICC image and turn-off.



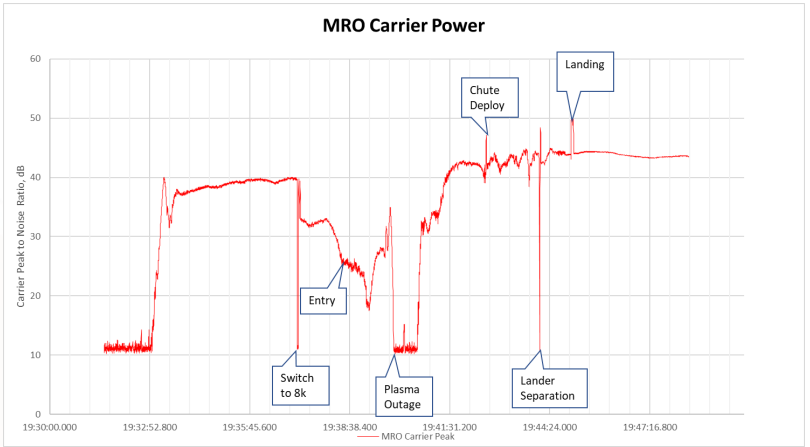


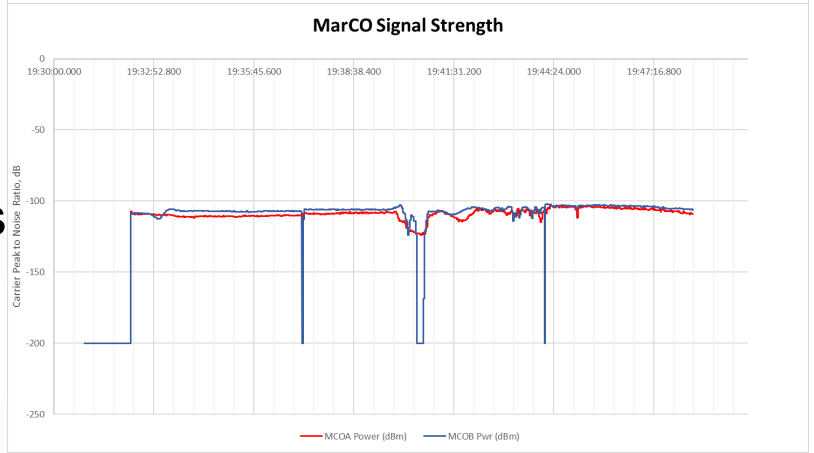
MarCO – Outgoing Mars Image

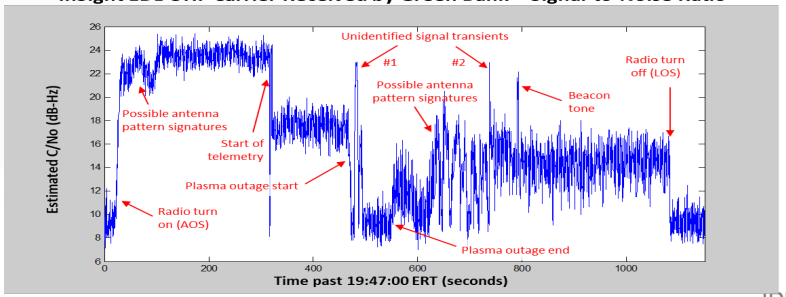


EDL Comm Results

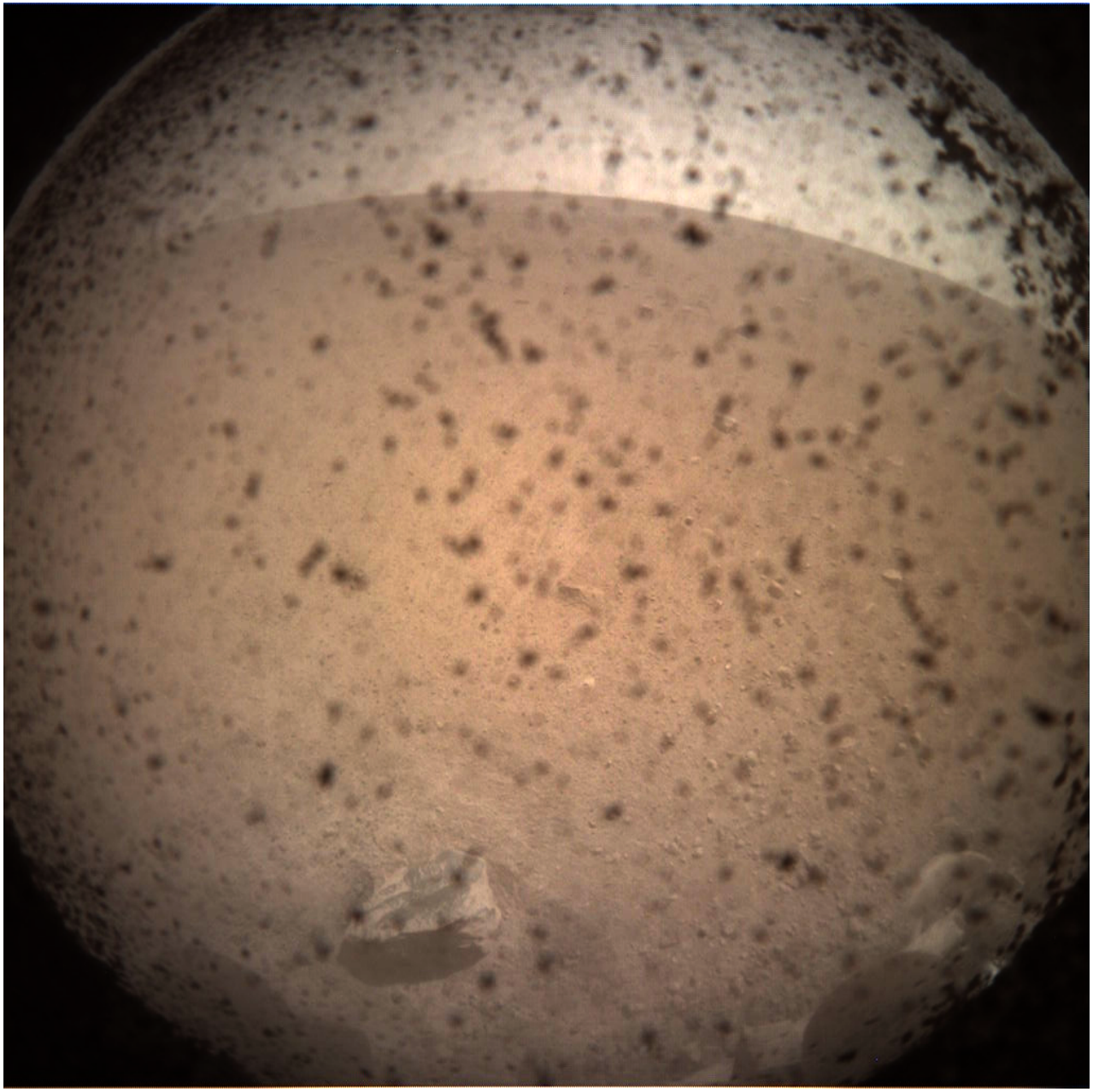
- MRO, MarCO A&B, Green Bank, and Effelsberg tracked UHF signal from UHF turn-on, through landing, to turn-off
- All assets saw plasma blackout ~46 seconds after entry
- Drop in MRO signal before plasma outage – being investigated
- HiRISE picture was unsuccessful
  - Insight left HiRISE FOV 2 seconds before image started
  - Image was overexposed due to dust in atmosphere, lighting conditions





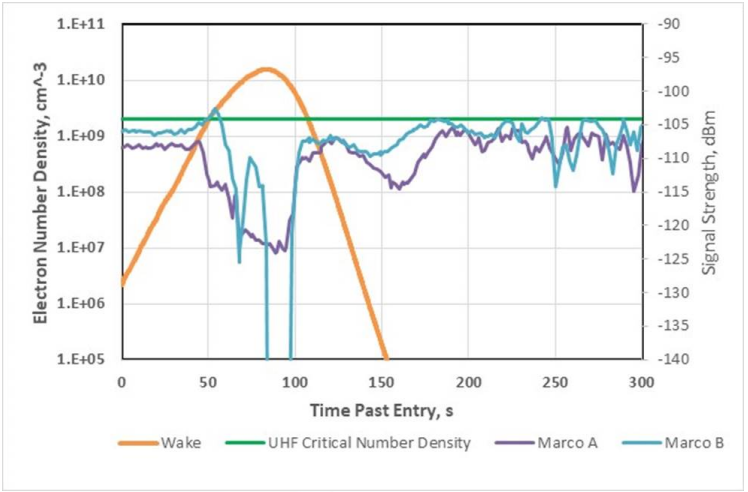


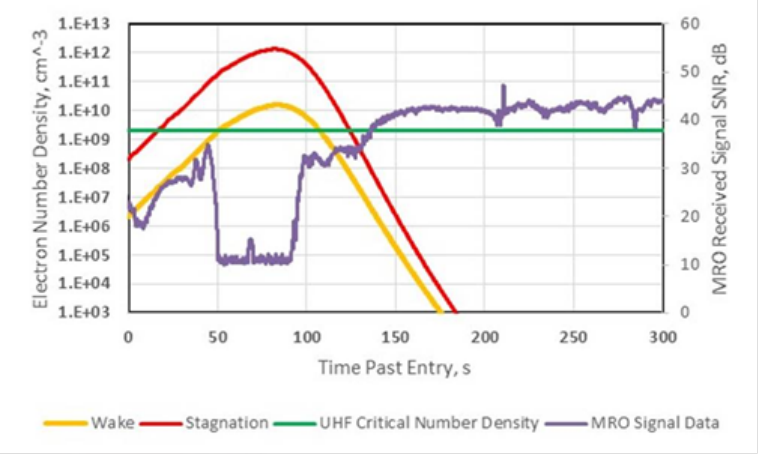
First Landed Image – returned via MarCO



Plasma Analysis

- All three orbiter receivers experienced signal degradation during “predicted” degradation period determined from parametric models as function of atmospheric relative velocity (Vrel) and atmospheric density (r_atm)
- Attenuation measured during degradation period (using signal level predicts) agrees with attenuation estimated from electron density profiles along signal line-of-sight generated from Ames DPLR CFD tool to within known uncertainty of electron number density estimates from DPLR.
- Early plasma onset may affect MRO signal close to heat shield





EDL Comm Results

- Telemetry was displayed in real-time, throughout EDL
- MRO Open-loop outage signal drop before plasma outage
  - May be due to: cross-polarization at high cone angles; Faraday rotation through ionosphere; plasma onset
- HiRISE Parachute Image Unsuccessful
- IF there had been a failure, sufficient data was received to analyze failure